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Thermal and Pasting Properties of Microwaved Corn Starch^{*}

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Corn starch with 15–40% moisture was irradiated at 0.17 or 0.5 W/g for 1 h using the sophisticated Ethos 1600 microwave apparatus that accurately controls temperature and wattage. Temperature of irradiated starch was measured during microwaving. Thermal and pasting properties were studied on dehydrated starch after microwave irradiation. Temperature increases were greatest during the first 10 min for starch at all moisture contents at both microwave power levels. Starch irradiated at 0.17 W/g had a temperature below onset gelatinization temperature (T_o) after 1 h. Higher temperatures were observed for starch with higher moisture content and microwaved at 0.5 W/g. Compared to native starch, starch with 15–40% moisture had higher T_o (measured using differential scanning calorimetry) and with 35–40% moisture had higher peak gelatinization temperature and lower enthalpy change of gelatinization. All paste viscosity parameters measured by the Rapid Visco Analyser were reduced and pasting temperature was elevated for starch irradiated at 0.5 W/g compared to native starch.

Keywords: Corn starch; Microwave irradiation; Physicochemical properties

1 Introduction

Starch is a major reserve polysaccharide of green plants. Pure starch can be obtained by simple processes and its abundance makes it an attractive industrial product to chemically or physically modify the starch structure and physicochemical properties. In the last decade, utilizing microwave irradiation to modify starch has received increased attention.

Research on modifying starch using microwave irradiation has recently focused on low-moisture starch because starch gelatinization is limited when starch moisture content is below 25–30% [1]. Lewandowicz et al. [2] found after microwave irradiation of root and tuber starch that dry starch samples showed a marked decrease in viscosity while gelatinization temperature remained unchanged. Starch samples up to 20% moisture had less pronounced viscosity decrease. Starch samples with moisture content of 20–35% showed both a decrease in viscosity and an increase in gelatinization temperature. Starch samples irradiated in sealed beakers had a much higher rise in gelatinization temperature.

In studies irradiating low-moisture cereal starches a decrease in viscosity and an increase in pasting temperature was found for wheat and normal corn starch, but waxy

corn starch was unaltered [3]. Degree of crystallinity of wheat and normal corn starch decreased while waxy corn starch remained unchanged, and all starches retained the A-type X-ray diffraction pattern. A substantial rise in onset gelatinization temperature (T_o) was observed for wheat (13.8°C), normal corn (11.3°C) and waxy corn starch (6.0°C). The enthalpy change of gelatinization (ΔH) decreased substantially for irradiated wheat and normal corn starches but waxy corn starch showed an insignificant decrease. Changes in physicochemical properties of cereal starches induced by microwave irradiation were less pronounced than for root and tuber starches [2–3]. In contrast to these findings, Zylema et al. [4] reported that the onset gelatinization temperature did not differ for microwaved wheat starch and a decrease in gelatinization temperature of potato starch after microwave irradiation has also been reported [5]. Microwave irradiation of lentil starch with 25% moisture was found to reduce all amylographic viscosities [6].

Despite recent research focusing on modifying low-moisture starch by irradiation over a long duration, Ndife et al. [7] demonstrated changes in gelatinization rates of cereal starches at 50–67% moisture and Muzimbaranda and Tomasik [8] observed decrease in paste viscosity of microwaved irradiated corn, potato and cassava starch at 94–96% moisture.

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Heating of non-irradiated low-moisture content starch has also been reported to alter starch properties [9]. Normal maize, waxy maize, dull waxy maize and amylo maize V starches with 30% moisture heated for 16 h at 100°C had an increase in X-ray intensity and gelatinization temperature while ΔH and paste viscosity were unaltered. Heat treatment of potato and wheat starch with 18–27% moisture at 100°C has been shown to result in broadening of gelatinization temperature range, increase in gelatinization temperature and decrease in ΔH with increasing moisture content [10–11]. Similar to irradiated starch, heat-treated non-irradiated low-moisture potato starch had greater changes in starch properties compared to wheat starch.

The temperature of low-moisture starch during microwave irradiation has also been measured [2]. A strong correlation was found between water content of starch and time-temperature profile. Starch with very low moisture content (1–5%) had rapid rise in temperature, while starch with 7–15% moisture content showed a much less pronounced temperature rise. Starch with more than 20% moisture exhibited a plateau with a longer plateau interval duration observed for starch with higher moisture content. Plateau interval duration was longer in samples irradiated in sealed beakers compared to open beakers.

Starch molecules subjected to microwave irradiation may undergo excitation by specific radiation frequencies resulting in dielectric coupling that causes reorientation of molecules, molecular friction and changes in hydration. All these factors lead to absorption of microwave energy that is transformed into heat. The vast majority of research to date on modifying starch by microwave irradiation has used a common domestic microwave appliance as radiation source which typically cannot maintain a constant microwave power. In our study, we utilize the sophisticated Ethos 1600 microwave apparatus by Milestone Inc. that is able to accurately control pressure, microwave power and temperature of starch samples during the microwave process. The sophisticated microwave will be used to study low-moisture corn starch time-temperature profiles, and the thermal and pasting properties while accurately maintaining microwave power.

2 Materials and Methods

Corn starch used for this study was obtained from Sigma Chemical Co. (St Louis, MO, product # S4126). Corn starch, taking into consideration its intrinsic water content, was adjusted to 15, 20, 25, 30, 35 or 40% moisture content using deionized water. Three replicates

of each starch moisture treatment were studied. Each starch sample was placed in a sealed 100 mL perfluoroalkoxy-Teflon reactor vessel. For each microwave run, ten reactor vessels (eight vessels consisting each of a randomly selected moisture treatment and two vessels used to ensure equal weight of starch and water per run) were inserted into a carousel and placed in a sophisticated microwave apparatus (Ethos 1600, Milestone Inc., Monroe, CT) for 1 h at microwave power of either 0.17 W/g or 0.5 W/g. A Teflon stirrer bar was placed in each reactor vessel with a stirring rate of 95 rpm used. Following microwave treatment, corn starch samples were washed twice with absolute ethanol and then recovered by filtration using Whatman No. 4 filter paper. The purified starch cake was dried in a convection oven at 35°C for 48 h.

2.1 Differential scanning calorimetry (DSC)

Thermal properties of microwaved corn starches were determined using a differential scanning calorimeter (DSC 2920 modulated, TA Instruments, New Castle, DE). Approximately 4 mg of corn starch was weighed in a stainless steel pan, mixed with 12 mg of deionized water and sealed. Sample was allowed to equilibrate for 2 h and scanned at a rate of 10°C/min over a temperature range of 10–200°C. An empty pan was used as reference. All thermal properties were carried out in triplicate for each replicate of each microwaved corn starch treatment.

2.2 Rapid Visco Analyser (RVA) measurements

Microwaved corn starch pasting properties were analyzed using a Rapid Visco Analyser (RVA-4, Foss North America, Eden Prairie, MN) using a method previously used for starch suspensions [12]. A corn starch suspension (8%, w/w), in duplicate for each replicate, was prepared by weighing corn starch (2.24 g, dry starch basis) into a RVA canister and making up the total weight to 28 g with deionized water. The suspension was equilibrated at 30°C for 1 min, heated at a rate of 6.0°C/min to 95°C, maintained at that temperature for 5.5 min, and then cooled to 50°C at a rate of 6.0°C/min. Constant paddle rotating speed (160 rpm) was used throughout the entire analysis except for a speed of 960 rpm for the first 10 s to disperse the sample.

2.3 Statistical analysis

All statistical significance tests were calculated using SAS [13] and applying Tukey difference test [14].

3 Results and Discussion

3.1 Temperature of starch during microwave irradiation

The temperature of corn starch with 30% moisture irradiated at various microwave power levels is shown in Tab. 1. Temperature of starch increased progressively with both irradiation time and power. Starch irradiated at 1.67 and 2.00 W/g resulted in combustion of starch within 50 and 20 min, respectively. Since high microwave power charred or caramelized corn starch and previous research using domestic microwaves had found optimum conditions at 0.5 W/g or lower for tuber and cereal starches [2], we decided also to avoid exceeding 0.5 W/g for our study.

Corn starch was microwaved at 0.17 W/g to study whether low microwave power for a long duration results in modification of starch properties. For corn starch at all

moisture contents studied, temperature increased most strongly in the first 10 min, and subsequent increases were gradual (Tab. 2). None of the corn starch samples with 15–40% moisture reached a temperature above the gelatinization temperature during the entire 60 min of irradiation, although the temperature of corn starch at 40% moisture was at optimal temperature for annealing [15] during the final 20 min of irradiation. The low moisture content will not inhibit annealing as previous studies have annealed starch at 16% moisture [16]. A higher temperature of corn starch with increasing moisture content was observed, but only the temperature after 60 min of irradiation showed any significant differences among the various moisture contents studied.

Microwave-irradiated corn starch at 0.5 W/g showed marked differences in temperature with respect to irradiation time and starch moisture content (Tab. 3). All

Tab. 1. Temperature [°C] of corn starch with 30% moisture microwaved at various power levels for 1 h^x.

Microwave Power [W/g]	Time [min]						
	0	10 ^y	20	30	40	50	60
0.50	24.4	63.5 ^e	78.5 ^e	88.8 ^d	96.8 ^d	103.6 ^d	110.4 ^c
0.63	21.4	75.3 ^d	89.7 ^d	97.8 ^c	104.2 ^c	109.8 ^c	114.6 ^b
1.00	21.6	89.7 ^c	112.2 ^c	127.4 ^b	137.0 ^b	141.8 ^b	147.4 ^a
1.67	21.6	125.0 ^b	144.1 ^b	158.7 ^a	173.1 ^a	182.7 ^{a*}	
2.00	22.8	144.6 ^a	187.1 ^{a*}				
	$P = 0.85^z$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$

* Combustion of starch occurred.

^x Temperature measurements are the mean of two analyses.

^y Values with different letters denote differences at the 5% level of significance for each comparison between moisture contents in the respective column.

^z P represents the probability of F-statistic exceeding expected.

Tab. 2. Temperature [°C] of corn starch with varying moisture content microwaved at 0.17 W/g for 1 h^x.

Moisture content	Time [min]						
	0 ^y	10	20	30	40	50	60
15%	24.0	35.3	42.1	45.7	47.3	48.9	50.1 ^{ab}
20%	26.4	36.5	42.1	44.9	47.3	48.1	48.5 ^b
25%	24.8	40.1	44.9	46.9	48.5	49.7	50.5 ^{ab}
30%	24.0	38.9	44.5	48.9	50.9	51.7	53.7 ^{ab}
35%	23.6	40.7	47.0	51.5	53.1	54.8	55.6 ^{ab}
40%	23.6	44.1	52.9	57.7	62.1	64.1	65.3 ^a
	$P = 0.96^z$	$P = 0.69$	$P = 0.25$	$P = 0.17$	$P = 0.07$	$P = 0.07$	$P = 0.05$

^x Temperature measurements of starch are the average of two replicates.

^y Values with different letters denote differences at the 5% level of significance each comparison between moisture contents in the respective column.

^z P represents the probability of F-statistic exceeding expected.

Tab. 3. Temperature [°C] of corn starch with varying moisture content microwaved at 0.5 W/g for 1 h^x.

Moisture content	Time [min]						
	0 ^y	10	20	30	40	50	60
15%	24.8	56.5 ^c	70.5 ^{cd}	79.3 ^{cd}	86.1 ^{bc}	92.9 ^{cd}	100.2 ^{bc}
20%	26.4	56.1 ^c	67.7 ^d	74.1 ^d	80.1 ^c	86.1 ^d	91.8 ^c
25%	27.2	60.9 ^{bc}	72.5 ^{bcd}	81.7 ^c	87.7 ^b	95.0 ^{bc}	101.8 ^{bc}
30%	24.4	63.5 ^{abc}	78.5 ^{bc}	88.8 ^b	96.8 ^a	103.6 ^{ab}	110.4 ^{ab}
35%	25.6	66.5 ^{ab}	79.3 ^b	89.3 ^b	97.0 ^a	103.0 ^{ab}	107.0 ^{ab}
40%	24.8	70.5 ^a	88.5 ^a	95.8 ^a	103.4 ^a	110.2 ^a	114.6 ^a
	$P = 0.59^z$	$P = 0.002$	$P = 0.0006$	$P < 0.0001$	$P = 0.0001$	$P = 0.0003$	$P = 0.001$

^x Temperature measurements of starch are the average of two replicates.

^y Values with different letters denote differences at the 5% level of significance each comparison between moisture contents in the respective column.

^z P represents the probability of F-statistic exceeding expected.

starch samples exhibited some particle aggregation after 1 h of microwave irradiation, with clumps of starch or layers of starch that peeled off observed at higher moisture contents and microwave power. Non-uniform gelatinization of microwaved starch producing chalky and pasty regions has been previously reported [7]. Similar to starch irradiated at 0.17 W/g, a greater increase in temperature of starch was observed after the first 10 min of irradiation compared with any other 10 min interval. Additionally, corn starch irradiated at 0.5 W/g had increasing temperature with increasing moisture content throughout the entire duration of irradiation. Starch samples for all moisture contents studied experienced a temperature increase well exceeding the gelatinization temperature. Significant differences in temperature of corn starch among the different moisture contents were observed at all 10 min intervals measured.

The greatest change in temperature of irradiated starch occurring in the first 10 min has been previously reported by Lewandowicz *et al.* irradiating starch at 0.5 W/g [2]. However, their study reports tuber starches with 17–35% moisture exhibiting a plateau after the initial temperature rise, with longer plateau intervals with higher moisture content. Although we observed a progressive decrease in the rate of temperature rise of irradiated corn starch, we did not observe any temperature plateaus. Additionally, in contrast to their findings, we observed higher temperatures for starch with higher moisture content. There could be several reasons to explain the observed differences. First, in our study we used a sophisticated microwave source that can very precisely control conditions whereas in Lewandowicz *et al.* [2] study, a domestic microwave oven was used, i.e. it is uncertain how well microwave power conditions were maintained or how variable the actual microwave wattage was from the power level set-

ting selected. Second, in our study a constant wattage was maintained without any oscillation (monomode), whereas domestic microwave appliances operate using oscillating wattage (multimode). This is not likely to explain the observed differences, because no difference in chemical reaction rates between monomode and multimode microwave power has been reported [17]. Third, in our study temperature probes were located within reaction vessels thereby providing precise temperature measurements of starch, whereas in their study the starch samples were removed from microwave and thermometers placed into the starch. Last, their temperature measurements were carried out using irradiated tuber starches, whereas corn starch was used in our study. Later research by Lewandowicz *et al.* [3] showed that cereal starch properties were less affected by microwave irradiation than tuber starches but the temperature of cereal starches was not measured.

3.2 Thermal properties of irradiated starch

Thermal properties of corn starch with varying moisture content irradiated at 0.17 W/g for 1 h are shown in Tab. 4. All thermal properties measured for native corn starch were similar to microwave irradiated starch with 20–35% moisture, but corn starch with either 15 or 40% moisture had higher T_o and lower ΔH . Corn starch with 40% moisture had significantly higher T_o and peak gelatinization (T_p) temperatures than starch with 20–35% moisture.

Corn starch irradiated at 0.5 W/g for 1 h exhibited greater changes in thermal properties, particularly at higher moisture contents (Tab. 5). T_o of the irradiated corn starch at all moisture contents studied was higher than that of native starch. Irradiation of starch with moisture content

Tab. 4. Thermal properties of corn starch with varying moisture content microwaved at 0.17 W/g for 1 h^v.

Moisture content	Starch thermal transition ^w		
	T_o [°C] ^{xy}	T_p [°C]	ΔH [J/g]
15%	69.4 ^{ab}	74.4 ^{ab}	11.4 ^{ab}
20%	67.7 ^c	73.3 ^b	13.0 ^{ab}
25%	67.9 ^c	73.3 ^b	13.0 ^{ab}
30%	68.8 ^{bc}	74.0 ^b	12.7 ^{ab}
35%	68.1 ^{bc}	73.3 ^b	13.2 ^a
40%	70.1 ^a	75.4 ^a	10.9 ^b
	$P = 0.0003^z$	$P = 0.001$	$P = 0.03$

^v Corn starch (~ 4.0 mg, dry flour basis) and deionized water (~12.0 mg) were used for the analysis; T_o , T_p , and ΔH are onset and peak gelatinization temperature, and enthalpy change of gelatinization, respectively.

^w Native corn starch T_o , T_p and ΔH were 67.9°C, 74.0°C and 13.2 J/g, respectively.

^x Values were calculated from three analyses for each of three reps.

^y Values with different letters denote differences at the 5% level of significance each comparison between moisture contents in the respective column.

^z P represents the probability of F-statistic exceeding expected.

Tab. 5. Thermal properties of corn starch with varying moisture content microwaved at 0.5 W/g for 1 h^v.

Moisture content	Starch thermal transition ^w		
	T_o [°C] ^{xy}	T_p [°C]	ΔH [J/g]
15%	69.1 ^c	74.4 ^c	11.6 ^{ab}
20%	68.6 ^c	74.0 ^c	11.4 ^{ab}
25%	69.2 ^c	74.6 ^c	13.8 ^a
30%	69.2 ^c	74.5 ^c	11.4 ^{ab}
35%	71.6 ^b	77.9 ^b	9.0 ^b
40%	75.8 ^a	81.3 ^a	4.1 ^c
	$P < 0.0001^z$	$P < 0.0001$	$P < 0.0001$

^v Corn starch (~ 4.0 mg, dry flour basis) and deionized water (~12.0 mg) were used for the analysis; T_o , T_p , and ΔH are onset and peak gelatinization temperature, and enthalpy change of gelatinization, respectively.

^w Native corn starch thermal properties are listed at footnote in Tab. 4.

^x Values were calculated from three analyses for each of three reps.

^y Values with different letters denote differences at the 5% level of significance each comparison between moisture contents in the respective column.

^z P represents the probability of F-statistic exceeding expected.

of 30% or less had no effect on T_p whereas T_p of 35 and 40% moisture content corn starch was significantly higher. A marked decrease in ΔH was observed for irra-

diated 35 and 40% moisture corn starch. The higher moisture content corn starches (35–40%) irradiated at 0.5 W/g had significantly higher T_o and T_p than lower moisture content starches (15–30%).

The elevated T_o of corn starch after microwave irradiation is in agreement with previous research [3]. However, our observed increase in T_o of just 1.5°C for corn starch with 30% moisture microwaved for 1 h at 0.5 W/g is considerably lower than the 11.1°C increase in T_o reported by Lewandowicz et al. [3] under identical conditions. We suspect the domestic microwave they used may not have accurately controlled the specified wattage based on the lowest power setting. Therefore the microwave wattage they exposed to corn starch was probably greater than 0.5 W/g since in our study microwave treatment of corn starch at 0.17 W/g resulted in only a 0.9°C increase compared to native starch. Corn starch with 40% moisture irradiated at 0.5 W/g had a 7.9°C increase in T_o which is nearing the large temperature elevations observed in the study by Lewandowicz et al. [3]. Additionally, we observed only a slight change in T_p and ΔH of microwaved corn starch with 30% moisture compared to native starch, whereas Lewandowicz et al. [3] found marked differences. The rise in gelatinization temperature has been previously suggested to be due to associations of amorphous amylose or configuration in granular structure with greater stability [3, 10].

3.3 Pasting properties of irradiated starch

Pasting properties of corn starch microwaved at 0.17 W/g are shown in Tab. 6. Compared to native corn starch, corn starch irradiated at 0.17 W/g had lower peak and final viscosities. The corn starch paste of the lowest moisture content studied (15%) had significantly higher peak viscosity and breakdown than that with the highest moisture content (40%). Setback viscosity of intermediate moisture content (25–35%) corn starch was significantly lower than that of starch with 40% moisture.

Marked differences in pasting properties of corn starch microwaved at 0.5 W/g were observed (Tab. 7). Compared with irradiated corn starch at all moisture levels studied, native corn starch had higher peak, final, trough, breakdown and setback viscosities. Pasting temperature of native starch was lower than that of starch irradiated at 0.5 W/g with 25–40% moisture. The greatest differences in pasting properties of irradiated corn starch were observed for the highest moisture content studied (40%) with significantly lower peak, final and setback viscosity than all other moisture contents studied. Corn starch with 40% moisture had a much longer peak time after microwaving compared to all other moisture contents studied.

Tab. 6. Pasting properties of corn starch with varying moisture content microwaved at 0.17 W/g for 1 h measured by Rapid Visco Analyser^x.

Moisture content ^v	Peak viscosity ^{wy}	Trough ^w	Breakdown ^w	Final viscosity ^w	Setback ^w	Peak time [min]	Pasting temperature [°C]
15%	153.8 ^a	93.3	60.6 ^a	168.0	74.7 ^{ab}	11.9 ^{ab}	84.9 ^a
20%	142.9 ^{ab}	89.9	52.8 ^{ab}	162.4	73.5 ^{ab}	11.6 ^{bc}	73.4 ^d
25%	144.2 ^{ab}	94.1	50.1 ^{ab}	167.1	73.1 ^b	11.4 ^c	74.7 ^{cd}
30%	142.9 ^{ab}	91.3	51.7 ^{ab}	163.2	71.9 ^b	11.9 ^{abc}	82.9 ^{ab}
35%	137.3 ^b	91.7	45.6 ^{ab}	160.3	70.6 ^b	11.6 ^{bc}	75.9 ^{bcd}
40%	136.4 ^b	92.8	43.6 ^b	161.5	82.2 ^a	12.1 ^a	82.2 ^{abc}
	$P = 0.009^z$	$P = 0.87$	$P = 0.03$	$P = 0.74$	$P = 0.01$	$P = 0.005$	$P = 0.001$

^v 8% (w/w) corn starch suspension measured in duplicate for all three reps.^w Viscosity measured in Rapid Visco-Analyser units (RVU), 1 RVU = 12 mPa s.^x Native corn starch peak viscosity, trough, breakdown, final viscosity, setback, peak time and pasting temperature was 158.1 RVU, 102.2 RVU, 55.9 RVU, 184.5 RVU, 82.4 RVU, 11.87 min and 84.1°C, respectively.^y Values with different letters denote differences at the 5% level of significance each comparison between moisture contents in the respective column.^z P represents the probability of F-statistic exceeding expected.**Tab. 7.** Pasting properties of corn starch with varying moisture content microwaved at 0.5 W/g for 1 h measured by Rapid Visco Analyser^x.

Moisture content ^v	Peak viscosity ^{wy}	Trough ^w	Breakdown ^w	Final viscosity ^w	Setback ^w	Peak time [min]	Pasting temperature [°C]
15%	128.1 ^a	75.1 ^a	53.0 ^a	124.2 ^a	49.1 ^a	11.8 ^c	84.3 ^d
20%	87.2 ^{bc}	53.9 ^b	33.3 ^b	91.0 ^c	37.1 ^{bc}	12.0 ^c	83.9 ^d
25%	116.6 ^a	77.7 ^a	38.9 ^b	127.0 ^a	49.3 ^a	11.9 ^c	87.1 ^c
30%	95.9 ^b	75.2 ^a	20.7 ^c	117.5 ^{ab}	42.2 ^{ab}	12.1 ^c	89.5 ^{bc}
35%	81.1 ^c	72.6 ^a	8.5 ^d	104.2 ^{bc}	31.5 ^c	13.7 ^b	90.2 ^b
40%	62.7 ^d	55.4 ^b	7.3 ^d	66.5 ^d	11.0 ^d	20.2 ^a	94.5 ^a
	$P < 0.0001^z$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$	$P < 0.0001$

^v 8% (w/w) corn starch suspension measured in duplicate for all three reps.^w Viscosity measured in Rapid Visco-Analyser units (RVU), 1 RVU = 12 mPa s.^x Pasting properties of native corn starch are listed in footnote of Tab. 6.^y Values with different letters denote differences at the 5% level of significance each comparison between moisture contents in the respective column.^z P represents the probability of F-statistic exceeding expected.

This is reflected in a completely different pasting profile in which the only slight breakdown in starch paste viscosity occurred much later than in the case of starch microwaved at lower moisture contents (Fig. 1). The highest moisture content corn starch studied (40%) also has a significantly higher pasting temperature than starches of all other moisture contents studied. There was a general trend for a higher pasting temperature of corn starch with increasing moisture content.

An increase in pasting temperature and decrease in paste viscosity of corn starch with 30% moisture microwaved for 1 h at 0.5 W/g is in agreement with studies on tuber [2] and cereal [3] starches. Similar to the trends for thermal

properties, we did not observe the large decrease in paste viscosity reported by the other studies [2, 3] suggesting that microwave power conditions were not accurately maintained in their studies.

4 Conclusions

Corn starch with 15–40% moisture was irradiated at 0.17 or 0.5 W/g for 1 h using the sophisticated Ethos 1600 microwave apparatus, which can accurately control temperature and wattage. Temperature at both microwave power levels studied increased throughout the 1 h with the greatest rate change in the first 10 min. Higher micro-

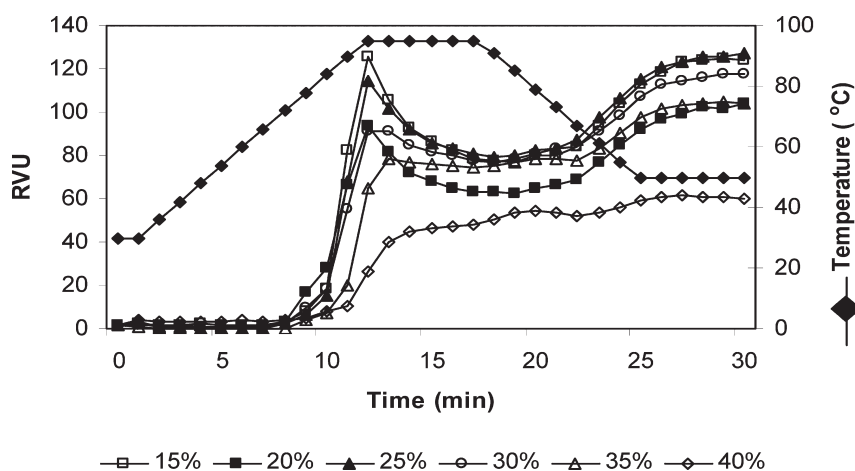


Fig. 1. Rapid Visco Analyser pasting profiles of corn starch with moisture content varying from 15–40% micro-waved at 0.5 W/g for 1 h.

wave power level and higher starch moisture content resulted in considerably higher starch temperature and some samples combusted within 1 h. Compared to native corn starch, starch with 35–40% moisture irradiated at 0.5 W/g had an increased onset and peak gelatinization temperature and a decrease in enthalpy change of gelatinization. Peak, trough, breakdown, final and setback viscosities were all lower for starch with 15–40% moisture irradiated for 1 h at 0.5 W/g compared to native starch. Although our study successfully modified the properties of corn starch using a microwave with controlled conditions, due to the length of irradiation time plus the occurrence of starch clumps and peeled skins, we would not recommend applications using low-moisture starch irradiated at low power for 1 h. Future studies should focus on modifying starch utilizing the greatest asset of microwave irradiation, the speed of reaction. In order to achieve faster reactions, starch may need to have higher moisture content or irradiated at higher microwave power.

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